

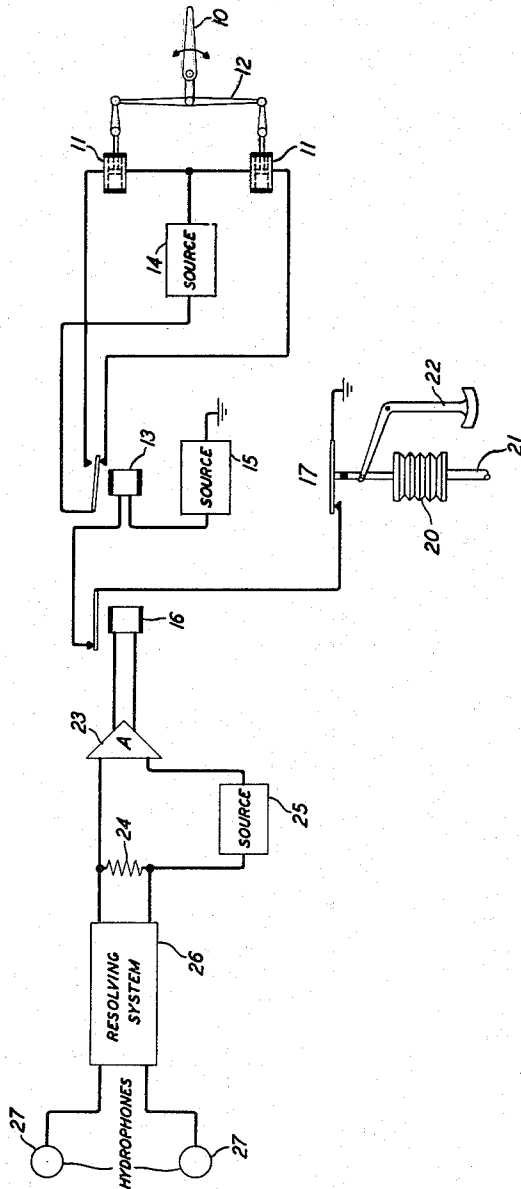
Aug. 15, 1961

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2,996,029

TORPEDO STEERING SYSTEM

Filed Nov. 20, 1944



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TORPEDO STEERING SYSTEM

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Filed Nov. 20, 1944, Ser. No. 564,360

10 Claims. (Cl. 114-25)

This invention relates to control circuits and more particularly to elevator control circuits for target signal responsive torpedo steering systems of the type disclosed in the application, Serial No. 555,523, filed September 23, 1944, of John C. Steinberg.

In systems of the type disclosed in the application above-identified, the rudder and elevator are subject to control, at least throughout the later portion of the run of the torpedo toward a target, in accordance with information as to the position of the target relative to the torpedo derived from signals, such as random and propeller noise, emanating from the target, the point in the path at which the rudder and elevator are committed to target signal control being determined by gate elements operable, for example, to enable the target signal responsive portions of the rudder and elevator control circuits when the signal level at the torpedo is of at least a preassigned magnitude. Each of the signal responsive portions comprises a pair of hydrophones mounted on the torpedo in such manner that the relative output of the two is a function of the angle in one dimension, i.e., horizontal or vertical, between the torpedo and target, and a resolving circuit for converting the hydrophone outputs in combination into a control signal of amplitude and polarity determined by the magnitude and sign respectively of the angle mentioned. The rudder and elevator are deflected, in one direction or the other, in accordance with the respective control signal to guide the torpedo to the target.

As pointed out in the application noted, while the torpedo is maneuvering to attack, the signals received by the hydrophones in the elevator control system may be such as to cause the device to broach at some distance from the target. Also, in the event of a miss of the target, the torpedo may be so oriented and the signal field thereadjacent may be such as to result in deflection of the elevator to steer the device in the vertical dimension along such path that it will fail to reattack. Certain controls for preventing such broaching and elevator action are disclosed in the application noted.

One general object of this invention is to improve elevator control circuits for target signal responsive torpedo steering systems.

More specifically, objects of this invention are to simplify such circuits including controls for preventing broaching of the torpedo and steering thereof, in the event of a miss, along a path not conducive to successful reattack, to increase the accuracy of attack for target signal guided torpedoes, to enable presetting of the attack angle in the vertical dimension, and to realize substantial uniformity of the maximum distance between target and torpedo at which the signal responsive portion of the elevator control system is enabled to effect steering.

In an elevator control circuit illustrative of one embodiment of this invention and adapted particularly for utilization in torpedoes intended for use against surface vessels, the direction of elevator deflection is determined by the condition of a relay, that is, specifically, when this relay is energized "down elevator" results and when the relay is released "up elevator" results, and the energizing circuit for this relay is subject to control by both the signal obtained from the target signal responsive portion of the elevator control circuit and a depth and pendulum

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mechanism which tends to effect deflection of the elevator to maintain the torpedo at a preassigned depth and level irrespective of the depth.

In accordance with one feature of this invention, the two controls, namely, the target signal and depth pendulum controls, are so associated relative to the energizing circuit for the relay that when the vertical angle between the target and the torpedo is of less than a preassigned magnitude, the depth pendulum mechanism controls the elevator to tend to steer the torpedo to the preassigned depth and maintain it level at this depth, whereas when this angle is of greater than the preassigned magnitude the relay is controlled to effect deflection of the rudder in the direction to steer the torpedo toward the target. Thus, once the torpedo, after launching, reaches such position relative to the target that the angle aforementioned is of at least the preassigned magnitude, the two controls produce such elevator action that the torpedo is aimed continuously substantially at this angle, in the vertical dimension, with respect to the target.

More specifically, in accordance with one feature of this invention, in a system for a torpedo intended for use against a surface vessel, means are provided for introducing a bias in the signal responsive portion of the elevator control circuit such that the signal obtained from this portion can result in "up elevator" only when the vertical angle between the target and torpedo is of at least the preassigned value and the two controls aforementioned are so correlated with respect to the relay that when, as a result of "up elevator," the torpedo tilts upwardly sufficiently to reduce the angle below the value noted the depth pendulum mechanism effects control of the relay to tend to steer the torpedo to level position at the preassigned depth. In effect, the steering of the torpedo in the vertical dimension is against target signal in one direction and against depth pendulum in the opposite direction whereby a substantially constant average angle of attack is obtained.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which the figure is a diagram, partly in functional block form, of a torpedo steering system illustrative of one embodiment of this invention.

The system illustrated comprises an elevator 10 which is deflectable in one or the opposite direction by a pair of solenoids 11, the armatures of which are coupled thereto by a suitable linkage 12 to steer the torpedo in the vertical dimension. The direction of deflection of the elevator is determined by which of the solenoids is energized and this in turn is determined by the condition of a control relay 13. Specifically, as shown, the two solenoids have one common terminal connected to a source 14, such as a battery, and the other terminal of each solenoid is adapted to be connected to the source over the armature and respective contact of the relay 13.

The energizing circuit for the relay comprises a source 15, such as a battery, the armature and contact of a relay 16 and a mechanically controlled switch 17.

The switch 17 is controlled by a depth and pendulum mechanism of generally known construction which comprises, for example, a bellows 20, the interior of which is in communication with the sea by way of a pipe or conduit 21 terminating at a port in the torpedo body, and a pendulum 22, both the bellows and pendulum being coupled to the switch as indicated. The elements involved are correlated so that the bellows tends to prevent departure of the torpedo in either direction from a preassigned depth and the pendulum tends to maintain the torpedo level.

The relay 16 is included in the output circuit of a direct

current amplifier 23, the input circuit for which includes a resistor 24 and a biasing source 25. The resistor 24 is associated with a resolving system 26, in turn associated with a pair of hydrophones 27. The hydrophones are mounted on the torpedo above and below the longitudinal axis thereof whereby the relative output of the two hydrophones is a function of the direction, in the vertical dimension and relative to the torpedo, of the source, that is the target, of the signals received by the hydrophones. The resolving system 26, which may be of the general organization disclosed in the application, Serial No. 491,795, filed June 22, 1943, of Donald D. Robertson, converts the outputs of the two hydrophones in combination into a potential across the resistor 24 related in polarity and proportional in amplitude to the sign and magnitude respectively of the vertical angle between the torpedo and the target and independent in amplitude of the signal level at the hydrophones. Thus, the control voltage applied to the amplifier 23 at any time is determined by the relation of the bias due to the source 25 and the potential impressed across the resistor 24 due to the target signals received by the hydrophones. The amplifier 23 and relay 16 are so associated that when the control voltage noted is of one polarity, the relay releases and when this voltage is of the opposite polarity, the relay operates.

As is apparent, subsequent to the launching of the torpedo, the condition of the relay 13, and hence, the direction in which the torpedo is steered in the vertical dimension is determined by the condition of both the switch 17 and the relay 16. Inasmuch as, as pointed out hereinabove, the potential across the resistor 24 is related in polarity and amplitude to the angle between the target and torpedo, for any particular bias due to the source 25, a balance between the bias and the potential across the resistor 24 can exist only when the angle noted is of a particular sign and polarity. Thus, the target signal responsive portion of the steering system may be utilized to affect steering control in accordance with target signals in one direction only, that is, up or down, depending upon the polarity of the bias.

In any particular system, poling relationship between target signal control, depth and pendulum control and other elements of the system must be observed. The character of these relationships will be understood from a consideration of an illustrative system for steering a torpedo in the vertical dimension against a surface vessel. In such a system, the solenoids 11 are associated with the relay 13 so that when this relay is energized, that is to cause engagement of its armature with the lower contact thereof in FIG. 1, down elevator results and when this relay releases, up elevator results. The depth and pendulum control is constructed and arranged so that the switch 17 is closed when the torpedo is level and above a preassigned depth, is opened if the torpedo is level and below this depth, is closed if the torpedo tilts upwardly at the preassigned depth and is opened if the torpedo tilts downward at this depth. The bias due to the source 25 is made of such polarity and amplitude that it is equal to and opposes the potential across the resistor 24 when the torpedo is below the target and at a preassigned vertical angle with respect thereto.

The operation of such illustrative system is as follows: At the time of launching the torpedo the switch 17 and relays 13 and 16 are in the condition shown in the drawing so that the energizing circuit for the relay 13 is under control of the depth and pendulum mechanism. If the torpedo is launched, for example from a surface vessel or submarine, at a depth above that for which the bellows 20 is set to operate the switch 17, the relay 13 remains operated, whereby down elevator is produced and the torpedo sinks to its preassigned running depth; if at the time of launching, as from a submarine, it is below this depth or if at any time in its run toward the target it sinks below this depth the bellows 20 operates to open the switch 17

whereby up elevator is produced and the torpedo rises to the preassigned running depth.

When the torpedo is at or reaches such position relative to the target that the potential across the resistor 24 overcomes the bias due to the source 25, the relay 16 operates to open the energizing circuit for the relay 13 whereby up elevator is produced. Thus, when the torpedo reaches such position, it is guided to the target under combined target signal and pendulum and depth control. Specifically, when such position is reached, the relay 16 operates to disengage the armature thereof from the contact, whereby up elevator is produced and the torpedo is steered upwardly. Consequently, the angle between the target and torpedo is decreased and the potential across the resistor 24 falls below the bias due to the source 25 and, as a result, the relay 16 releases to close its contact. When the torpedo is tilted upwardly, the switch 17 is closed by the pendulum and depth control. Hence, when the angle between target and torpedo decreases sufficiently to result in release of the relay 16, the energizing circuit for the relay 13 is closed and down elevator results. As the torpedo is steering downwardly, the angle between target and torpedo increases and operation of the relay 16 results so that up elevator is produced. The sequence of operations of relay 16 and switch 17 is repeated so that, as will be apparent, the elevator control transfers between the target signal on the one hand and the pendulum and depth control on the other. The effective result is that the elevator is actuated to guide the torpedo to the target by aiming the torpedo at a substantially constant average angle with respect to the target.

Inasmuch as the torpedo proceeds at a prescribed running depth under depth and pendulum control until the vertical angle between it and the target is such as to result in a potential across the resistor 24 sufficient to overcome the bias due to the source 25, the bias determines the maximum distance between the torpedo and target for which target signals can affect control of the elevator. Thus, in one aspect the relay 16 is controlled to function as a gate element for determining the range at which the target signal responsive portion of the steering system is enabled to exert steering control. Inasmuch as, as has been pointed out heretofore, the potential appearing across the resistor 24 is substantially independent of the target signal level at the hydrophone, it will be appreciated that a substantially uniform range is realized for a variety of targets. Advantageously, the bias is made such that the range is relatively small, for example of the order of 100 yards, whereby the probabilities of a miss are reduced.

It will be appreciated also that the bias, in effect, determines the attack angle in that as a result thereof the torpedo is steered in the vertical dimension so that it tends to be aimed at a constant angle, determined by the bias, relative to the target. A fairly large angle is conducive to accuracy of attack and any desired angle may be realized by appropriate setting of the bias.

As pointed out in the application of John C. Steinberg, hereinabove identified, the possibility exists that a target signal guided torpedo may broach at some distance from the target when it is maneuvering to attack. In a system constructed in accordance with this invention, this possibility is substantially reduced because of the limitation, due to the bias, upon the minimum angle between target and torpedo at which the target signal responsive portion of the system can be enabled.

As pointed out also in the application noted, in the event of a miss of the target, the torpedo may reach such position that target signal control would tend to steer the device into a vertical dive. Such undesired steering is prevented in systems constructed in accordance with this invention for the reason the target signals can produce only up elevator and, therefore, diving under target signal control is impossible.

It will be appreciated further that in the event the torpedo provided with an elevator steering system con-

structed in accordance with this invention misses the target, it will sink to a substantial depth under pendulum and depth control before the angle between it and the target is sufficient to result in balance of the relay 16. While it is thus sinking, the rudder control may operate to turn the torpedo through a substantial angle in the horizontal dimension to bring it within the effective signal field of the target. Thus, the action is such as to reorient the torpedo in a manner conducive to successful reattack before the signal responsive portion of the elevator control system is reenabled.

Further, inasmuch as only upward steering due to target signal control can be produced, it will be appreciated that protection is afforded to the submarine from which the torpedo is launched, provided that the submarine is below the running depth.

The system illustrated has been described above with particular reference to a torpedo intended for use against a surface vessel. It will be understood, of course, that the invention may be embodied also in systems for torpedoes intended for use against submerged submarines, by proper poling of the switch 17 and relays 13 and 16. Also, although in the specific system illustrated and described, the bias has been introduced in the input circuit for the direct current amplifier 23, it may be introduced at another point in the steering system, for example at the input to the resolving system 26. It will be understood further that the system shown and described is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A steering system for a moving body, comprising a steering member, actuating means for deflecting said member in one or the opposite direction, a normally closed energizing circuit for said actuating means associated therewith in such manner as to produce deflection of said member in said one direction when the circuit is closed and to produce deflection of said member in said opposite direction when the circuit is opened, means responsive to signals emanating from a source for opening said circuit only when the angle between the body and said source is of at least a preassigned value and sign, and means for opening said circuit whenever said body departs from a prescribed positional condition.

2. A steering system for a moving body, comprising an elevator, actuating means including a relay, for deflecting said elevator in one direction when the relay is energized and deflecting said elevator in the opposite direction when said relay is released, an energizing circuit for said relay, means responsive to signals emanating from a source for opening said circuit only when the vertical angle between the body and source is of a prescribed sign and of at least a preassigned magnitude, and means for opening said circuit whenever said body departs in one direction from level position.

3. A steering system for a moving body, comprising an elevator, actuating means for deflecting said elevator in one or the opposite direction, a normally closed energizing circuit for said actuating means associated therewith in such manner that when said circuit is closed said elevator is deflected in said one direction and when said circuit is open said elevator is deflected in said opposite direction, said circuit including a pair of serially connected switches, means for opening one of said switches when the body departs in one direction from a preassigned level in the vertical dimension, means for opening said one switch when said body tilts in the opposite direction with reference to said preassigned level, and means responsive to signals emanating from a source for opening the other of said switches only when the vertical angle between the body and said source is of at least a preassigned magnitude and of preassigned sign.

4. A steering system for a torpedo, comprising an elevator, actuating means for deflecting said elevator to

steer the torpedo in one or the opposite direction in the vertical dimension, a normally closed circuit for controlling said actuating means to effect deflection of said elevator in said one direction to steer the torpedo downwardly when the circuit is closed and in said opposite direction when the circuit is open, said circuit including a pair of switches connected in series relation, means for opening one of said switches if the torpedo sinks below a prescribed depth, means for opening said one switch if the torpedo tilts downwardly, and means responsive to signals emanating from a target for opening the other of said switches when said torpedo is below the target and the vertical angle between the torpedo and the target is of at least a preassigned magnitude.

5. A steering system for a moving body, comprising a steering member, actuating means for deflecting said member in one or the opposite direction, a circuit for controlling said actuating means to effect deflection of said member in one direction when said circuit is open and in the opposite direction when said circuit is closed, a switch in said circuit, means responsive to signals emanating from a source for producing a potential of polarity and amplitude determined by the position of the source relative to the body, means for producing a biasing potential of fixed polarity and amplitude, and means for controlling said switch to close or open it in accordance with the difference of said first and biasing potentials.

6. A steering system for a torpedo, comprising an elevator, actuating means for deflecting said elevator, a circuit for controlling said actuating means to produce up elevator when the circuit is open and down elevator when the circuit is closed, said circuit including a switch, means responsive to signals emanating from a target for producing a potential of polarity and magnitude determined by the signal and amplitude respectively of the vertical angle between the torpedo and the target, means for producing a biasing potential of fixed polarity and amplitude, and means for controlling said switch to open or close it in accordance with the difference of said first and biasing potentials, the polarity of said biasing potential being such that when it exceeds said first potential said controlling means effects closing of said switch.

7. A steering system for a torpedo, comprising an elevator, a first means for controlling said elevator to prevent the torpedo from sinking to below a preassigned depth, a second means for controlling said elevator to maintain said torpedo level, and means including said second means and means responsive to signals emanating from a target and operating conjointly with said second means for controlling said elevator to aim the torpedo at a constant angle of preassigned magnitude relative to the target.

8. A steering system for a torpedo, comprising an elevator, and means for controlling said elevator to aim the torpedo at a substantially constant average vertical angle relative to the target after the torpedo reaches a position relative to the target such that the vertical angle between the torpedo and target is of at least a preassigned magnitude, said controlling means comprising a first control means responsive to signals emanating from the target for controlling said elevator to steer the torpedo upwardly when the torpedo is at a depth below that of the target and the vertical angle between torpedo and target is of greater than said preassigned magnitude and a second control means for controlling said elevator to steer the torpedo downwardly toward level position at a prescribed depth when the vertical angle between torpedo and target is of less than said preassigned magnitude.

9. A steering system for a moving body, comprising a steering member, actuating means including a relay for deflecting said member in one direction when the relay is operated and in the opposite direction when said relay is released, an energizing circuit for said relay including a switch and a second relay having its armature and contact connected in series relation with said switch, an am-

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plifier having an output circuit including the energizing winding of said second relay and having an input circuit, means for impressing a bias of fixed polarity and magnitude upon said input circuit, means responsive to signals emanating from a source for impressing upon said input circuit a potential related in polarity and proportional in amplitude to the sign and magnitude respectively of the angle between the body and source, said bias corresponding in polarity and amplitude to a preassigned angle between the body and source whereby said second relay is subject to control in accordance with said potential only when the body is at an angle of prescribed sign and magnitude with respect to said source, and means for controlling said switch in accordance with a positional condition of said body.

10. A steering system for a torpedo, comprising an elevator, means including a relay for producing up elevator when the relay is released and down elevator when said relay is energized, an energizing circuit for said relay including a switch and a second relay having its armature and contact connected in series relation with said switch, pendulum means for closing said switch when the torpedo tilts upwardly, an amplifier having an output circuit including the energizing winding of said second relay

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and having an input circuit, said amplifier and second relay being so associated that when the potential impressed upon said input circuit is of one polarity said second relay is operated to disengage said armature from said contact and when said potential is of the opposite polarity said second relay is operated to cause engagement of said armature with said contact, means for impressing a biasing potential of preassigned amplitude and of said opposite polarity upon said input circuit, and means responsive to signals emanating from a target for impressing upon said input circuit a potential corresponding in polarity and proportional in amplitude to the sign and magnitude respectively of the vertical angle between said target and the torpedo.

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